

## 23. Particles 3- fogs

Wednesday, November 16, 2022

### Today:

Particles - how to get/make them

Finish air, then talk about particles in water.

Please do the 'Artist Statement' ASAP. Drop dead deadline is Dec 2, but earlier will be very helpful.

#### Dry Ice



Clicker: What in the fog is scattering light?

1. Water aerosol 36% 78%
2. Dry ice aerosol 10% 6%
3. Dry ice particles 5% 1%
4. Carbon dioxide droplets 47% 6%

#### Dry Ice Vapor: Dry ice = solid CO<sub>2</sub>

Sublimates (solid to gas) at 1 atm, -78 C (-109 F)

<http://www.dryiceinfo.com/fog.htm>

Submerge in hot water: much water fog created.

Cold stage fog:



**A theater fog machine is generally a 30 to 55-gallon metal or plastic water container with a 110-volt or 220-volt water heater to keep the water hot. Dry ice is placed in a bucket with holes to allow hot water to enter. Fog production drops for water temperature < 50 F.**

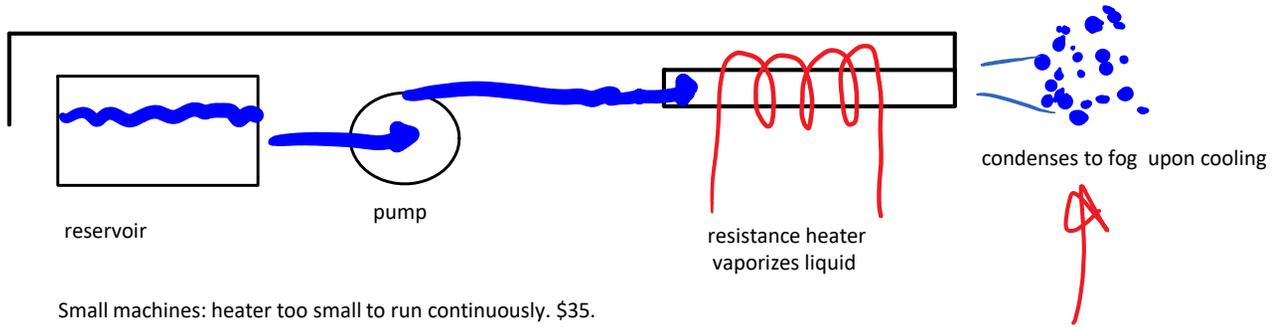
From <https://www.dryiceinfo.com/fog/>

\$2000 or so for a theater sized machine.

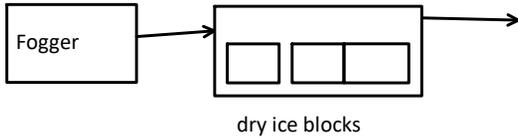
Safety: DO NOT SEAL DRY ICE IN A RIGID CONTAINER. EVER. Expands ~1000x.

*60 Pounds of Dry Ice and a Swimming Pool*, 2007. [http://www.youtube.com/watch?v=uHXA9ON6igk&feature=youtu.be\\_gdata\\_player](http://www.youtube.com/watch?v=uHXA9ON6igk&feature=youtu.be_gdata_player)

Warm Stage fog = Water + glycerin or propylene glycol. Additive slows evaporation  
 Club style fog machine. Physics are the same as e-cigarettes, vape



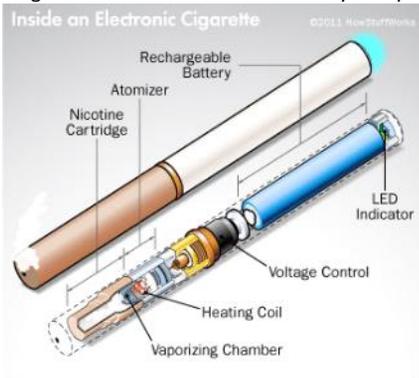
Small machines: heater too small to run continuously. \$35.



For fog-on-the-ground: chillers  
 Approximately 1 micron diameter droplets.

Yoshida, T., Y. Kousaka, and K. Okuyama. "A New Technique of Particle Size of Aerosols and Fine Powders Using an Ultramicroscope." *Industrial and Engineering Chemistry, Fundamentals*, Ind. Eng. Chem. Fundam. (USA), 14, no. 1 (February 1975): 47–51.

Large machines: can run continuously. For professional stage and theaters. \$1000. Mfg: Roscoe, Le Maitre. 1 gallon lasts 4 hrs, \$30.



E-cigarettes also use propylene glycol fluid. Same physics as fog machines.

\$10?

<http://science.howstuffworks.com/innovation/everyday-innovations/electronic-cigarette1.htm>

Austin L is a vape artist. Builds his own custom vape device: <https://www.youtube.com/watch?v=Syccl7rd3Lk>

Anonymous clicker: Do you vape?

- a) No, never 53%
- b) Tried a couple times 24%
- c) Sure, weekly
- d) Daily 12%
- e) No, but I'll try it now after seeing that video! 12%

Health effects of stage fog are minimal, except to asthmatics and opera singers.

Varughese, Sunil, Kay Teschke, Michael Brauer, Yat Chow, Chris van Netten, and Susan M. Kennedy. "Effects of Theatrical Smokes and Fogs on Respiratory Health in the Entertainment Industry." *American Journal of Industrial Medicine* 47, no. 5 (2005): 411–18. doi:10.1002/ajim.20151.  
 Wills, J. H., F. Coulston, E. S. Harris, E. W. McChesney, J. C. Russell, and D. M. Serrone. "Inhalation of Aerosolized Ethylene Glycol by Man." *Clinical Toxicology* 7, no. 5 (January 1974): 463–76. doi:10.3109/15563657408988020.

Health effects of vaping: Depends on the additives -

E-liquid concoctions usually include some mix of flavorings, aromatic additives and nicotine or THC (the chemical in marijuana that causes psychological effects), dissolved in an oily liquid base. "We think that some of the vaporized elements of the oil are getting deep down into the lungs and causing an inflammatory response," explains Broderick.

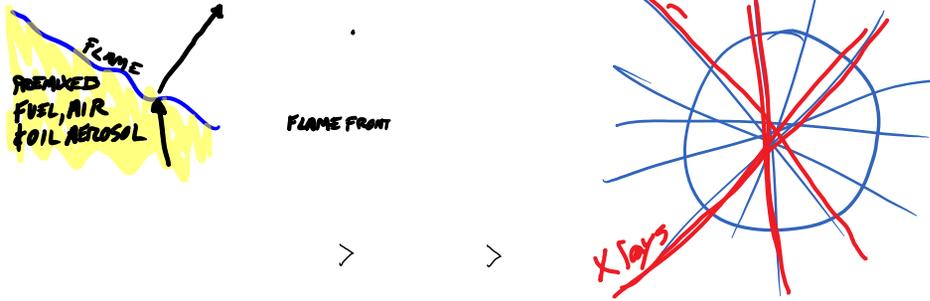
From <<https://www.hopkinsmedicine.org/health/wellness-and-prevention/what-does-vaping-do-to-your-lungs>>

<https://www.zamplebox.com/community/what-is-a-cloud-booster> Vegetable glycerin, for vape dilution, more fog.  
Glycerin = glycerine=glycerol. Non-toxic, water soluble, derived from soy or palm.

### C) Oil aerosols

Won't evaporate unless burned. Oil has low vapor pressure.  
Use medical or Bernoulli atomizer/nebulizer

Can be used to mark flame fronts. Illuminate fog with a laser sheet = "laser tomography" in 1980s.



CTomography

Danger! Oil aerosol will coat lungs = pneumonia = death

"Guidance-for-Aerosol-Applications-of-Silicone-Based-Materials.pdf." Accessed November 11, 2015.

<http://sehsc.americanchemistry.com/Research-Science-Health-and-Safety/Guidance-for-Aerosol-Applications-of-Silicone-Based-Materials.pdf>.

Discusses oil aerosol effects in general.

JEAN R. HERTZBERG, MEHDI NAMAZIAN, and LAWRENCE TALBOT. "A Laser Tomographic Study of a Laminar Flame In a Karman Vortex Street." *Combustion Science and Technology* 38 (1984): 205-216.

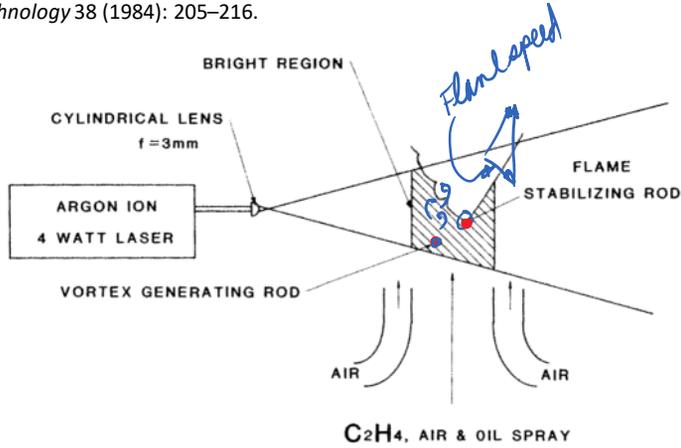


FIGURE 1 Experimental apparatus. The bright region is a cloud of oil droplets illuminated by the laser.

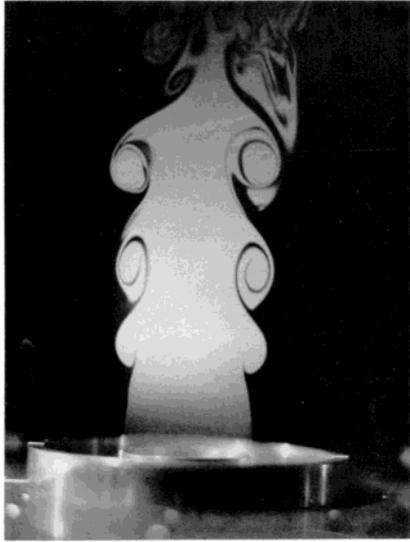


FIGURE 4 Example of tomography. Free jet, 1.2 m/s, issuing into stagnant room air.

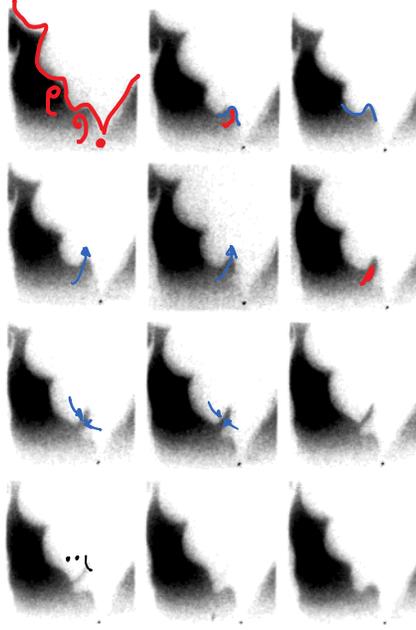


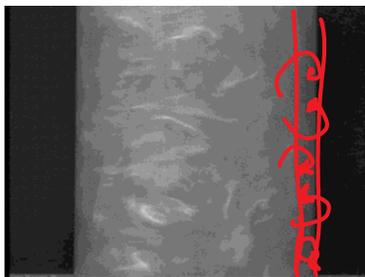
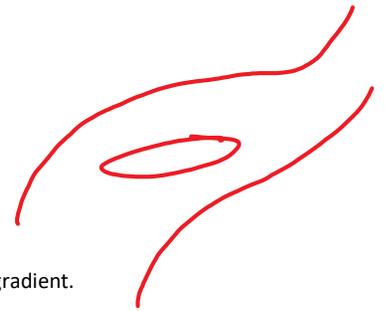
FIGURE 6 Example of tomography with combustion: from high-speed 16 mm film. The flame appears as the boundary of the dark V-shaped region. One complete cycle of interaction with vortex street is shown.

## Particles for Water

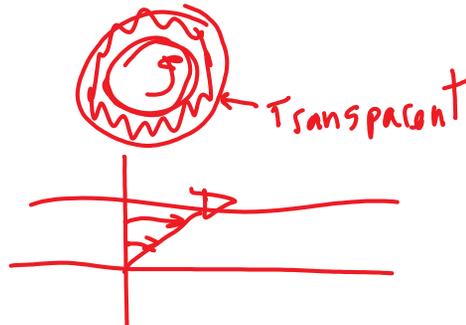
### Rheoscopic fluids:

Pearl Ex (art pigment,  $\text{TiO}_2$  coated mica).

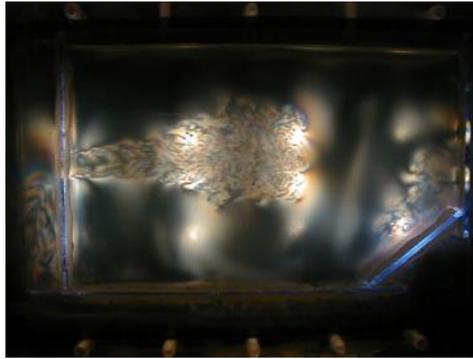
- 'Pearl Swirl' \$5/gallon from Steve Spangler Science  
Shiny opaque or translucent particles, crystal flakes,  $\sim 10 \mu\text{m}$  size, aligns with shear gradient. Used in soaps, shampoos  
<https://www.youtube.com/watch?v=vrTM9O6owII>  
Probably the same as:  
Stearic acid crystals extracted from shaving cream,  
Borrero-Echeverry, Daniel, Christopher J. Crowley, and Tyler P. Riddick. "Rheoscopic Fluids in a Post-Kalliroscope World." *Physics of Fluids* 30, no. 8 (August 1, 2018): 087103.  
<https://doi.org/10.1063/1.5045053>.



Taylor - Couette



'Blackstock' fluid, now 'KaleidoFlow Rheoscopic Fluid'



andesite clay

[http://buphy.bu.edu/~duffy/thermo/4820\\_77.html](http://buphy.bu.edu/~duffy/thermo/4820_77.html)

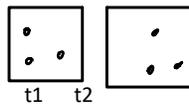
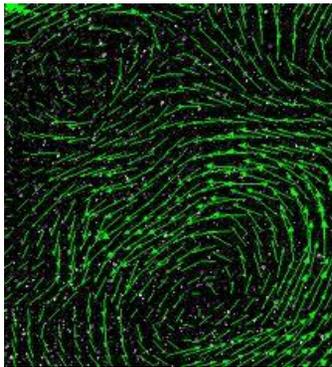
Streaming birefringence, seen when viewed between polarizing filters  
 Has 2 indices of refraction  
 Suspension of microscale mica flakes.

<http://www.laminarsciences.com/>  
 Bob Blackstock

### For individual particle images (PIV)

Individual particles are seen. Can be qualitative or quantitative (Particle Image Velocimetry, PIV).  
 Two images made, close together in time

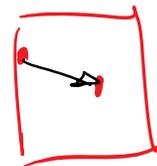
[http://fiji.sc/wiki/index.php/File:Surface\\_wave.gif](http://fiji.sc/wiki/index.php/File:Surface_wave.gif)



Divide image into subwindows

Cross-correlation gives displacement vector

$$\frac{\Delta \vec{x}}{\Delta t} = \text{VELOCITY}$$



Pasted from <[http://www.google.com/images?q=particle+image+velocimetry&hl=en&client=firefox-a&hs=NUI&rls=org.mozilla:en-US:official&prmd=ivnsb&source=lnms&tbs=isch:1&ei=9CY3TcyNH8L7lweQ2uSMAw&sa=X&oi=mode\\_link&ct=mode&cd=2&ved=0CBAQ\\_AUoAQ&biw=993&bih=412](http://www.google.com/images?q=particle+image+velocimetry&hl=en&client=firefox-a&hs=NUI&rls=org.mozilla:en-US:official&prmd=ivnsb&source=lnms&tbs=isch:1&ei=9CY3TcyNH8L7lweQ2uSMAw&sa=X&oi=mode_link&ct=mode&cd=2&ved=0CBAQ_AUoAQ&biw=993&bih=412)>

[https://commons.wikimedia.org/wiki/File:Cross\\_Correlation\\_Animation.gif#/media/File:Cross\\_Correlation\\_Animation.gif](https://commons.wikimedia.org/wiki/File:Cross_Correlation_Animation.gif#/media/File:Cross_Correlation_Animation.gif)

### Solid Particle Sources

- Neutral buoyancy [
- Corn starch (diluted)
  - Glass or polystyrene microspheres. Specific size and density. \$\$
  - Latex bubbles
  - Rust (filtered)
  - Mica powder for makeup
  - Alumina, sold as polishing powder. Available in 1 to 100 micron size ranges
  - Wax beads (Pine Sol)
  - Pine pollen (floats on surface)
  - Lycopodium powder (also used as flash powder)
- <http://vimeo.com/89491724> Cymatics by Susie Sie